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WEST EUROPE REPORT

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ENERGY

EEC SUPPORTS ENERGY DEMONSTRATION PROJECTS

Paris SEMAINE DE L'ENERGIE in French 13 Oct 80 pp 1-2

[Article: "The General Direction of the CEE Public Information Service Has Just Published a Report for Europe on European Demonstration Projects in the Energy Field"]

[Text] The community generally only approves projects seeking to reduce Europe's energy dependence and which present real assets for training, development, and commercialization.

In the field of hydrocarbons the CEE approved 168 projects of the 300 presented by approximately 170 companies.

Total amount: 500 million UCE*

CEE financing: 183 million UCE

Community support was given to two-thirds for the development of modern production technologies seeking to facilitate access to new petroleum areas, to exploit known deposits. Sixteen percent of the support involves transport techniques, 15 percent geophysical techniques and drilling technologies. Finally 2 percent of the CEE assistance went to storing hydrocarbons. French and British firms were the most numerous to come forward as candidates.

In the field of coal CEE assistance will seek principally to support several projects concerning gasification and liquefaction of coal.

Aside from the Belgo-German experiment for subterranean gasification near Thulin and the British liquefaction installation to produce automobile fuel, the CEE's financial contribution to the French project for deep gasification, conducted by C de F, G de F, L'IFP and BRGM should be noted.

The selection of the 23 proposals received in Brussels will take place very soon.

Solar energy projects also attracted attention since 26 projects were approved of the 135 submitted. This shows the firms' fixation on this form of energy; it will cover 5 percent of our needs in 2000.

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* 1 UCE = 5.9 FF

Nevertheless, the CEE financial support in the field of energy conservation is the largest after hydrocarbons. Projects approved could permit the annual saving of approximately 100,000 tons of petroleum. They are very diverse, going from the heat pump to waste processing via a multitide of other very ingenious devices.

Support granted by the Community cannot exceed 40 percent of the total of the projects and are 100 percent reimbursable if used for commercial exploitation in the hydrocarbon field; 50 percent for other sectors. The developers undertake to publish the findings obtained from putting into operation new technologies. There were numerous candidates for Community assistance for the 1979-83 period. But it is to be noted that Europe Report is silent or almost silent concerning the nuclear field because of the difficulty in harmonizing the research programs in countries more or less involved in the sector. Perhaps the result of legislative elections favorable to the social democrats might permit Chancellor Schmidt to give a new impetus to the German effort. At all events the European Economic Community has a role to play. Recent declarations by Guido Bruner are eloquent from that viewpoint.

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CSO: 3102

FLUIDIZED-BED COMBUSTION: STATUS REPORT, CASE STUDIES

Frankfurt/Main ELEKTRIZITAETSWIRTSCHAFT in German 1 Sep 80 pp 642-650

[Article by Klaus-Peter Moeller, economist, Wolfgang Oest, political scientist and mathematician, and Wolfgang Stroebele, political scientist and mathematician, staff members of the ISP (Institute of Applied Systems Research and Prognosis, Inc.), Hanover: "Fluidized-Bed Furnaces in Thermal Power Planes--Two Cases Studies"]

[Text] The authors are staff members of the ISP in Hanover. On a contract for Ruhrkohle AG [Inc.] and in cooperation with the Erlangen KWU [Power Plant Union] and the Duesseldorf VKW [United Power Plants] they are investigating here the economy of operations at two thermal power plants with fluidized-bed furnaces. The model power plants investigated correspond to types which are relatively often encountered or to be used in the FRG. They are first of all studying the conversion of an oil-fired boiler plant to the fluidized bed and, next, a complete thermal power plant with connected long-distance heat network to supply an industrial and residential area, in hypothetical terms, in order to find how economical it is.

1. General Remarks

The electric power industry will during the coming decades be facing new requirements. The traditional areas of application of electric energy (current), which grew very much in the past, will in the near future grow only very slowly. On the other hand, looking at an overall energy-policy concept, which seeks to pursue directions "away from oil," new areas of application will also be opened up for electrical current. Because oil and gas dominate especially on the low-temperature heat market, we come to the question of possible concepts here.

The heat market mentioned here is, in terms of the order of magnitude, between three and four times larger than the traditional current utilization area for power, light, and communication. If electrical current would thus very strongly penetrate into that sphere, we would be facing not only the need for building more power plants but we would also have a considerable shift in the seasonal load curve for power use during the winter months. Because electrical current for the heat market should not be pushed primarily in the form of night-time storage heating systems (5, 12, 15)--something which obviously makes sense--but because instead it

is interesting precisely in combination with the various forms of solar energy use, we also come to the next logical question dealing with ways in which population concentration areas are to be supplied with heat: here, heat pumps or solar roofs, collectors, etc., as a rule cannot be adequately used.

If the electric power industry wishes to cover only a very modest proportion of the heat market through heat pumps or other heating systems, then it must also be able to offer a concept for the population concentration areas. Simultaneous expansion of heat pumps in the rural areas and night-time current storage [battery] heating systems in the city would make the temperature dependence of the load curve even worse as the winter peak load keeps going up. As alternative we might look at a combined concept featuring the expansion of power-heat interconnection: thermal power plants near cities would supply the metropolital areas with long-distance heat and would generate the current which would drive heat pumps and solar systems in thinly-populated regions. Such thermal power plants in the vicinity of cities would have to be of average size, that is to say, between about 10 Mw all the way to more than 100 Mw, depending upon the long-distance heat potential.

Looking at the present-day political landscape, which is very much sensitized regarding environmental protection requirements, it would seem that plans for coal-fired thermal power plants near cities could hardly be implemented. Fluidized-bed burning offers one opportunity for meeting environmental protection requirements for coal-fired power plants near cities in a manner similar to the TA [technical conditions] for air. The concept outlined above would thus boil down to erecting fluidized-bed-fired medium coal-using thermal power plants and thus attaining several advantages all at once: a counterpressure system would generate electrical current synchronously with the long-distance heat requirement of the metropolitan areas and that electrical current would fit in with the additional load profile of the heat pumps and other solar systems which supply the open country; the environmental protection requirements can be complied with, thanks to the fluidized-bed technology; the capital costs of such a plant are relatively favorable so that even electrical current from hard coal looks attractive from the operator's viewpoint. Because it is also possible to burn ballast-rich and sulfur-containing coal grades and because coal is available from domestic supplies, the supply situation is much more reliable than in the case of other energy sources. The extent to which this concept could be economical and environmentally safe in a specific model case is described below (Chapter 4).

A second problem deriving from rising oil and gas prices confronts the industrial power industry which so far has frequently been operating its systems on the basis of heavy heating [fuel] oil or natural gas. Here, the boilers might possibly have to be exchanged against coal boilers in case of any renovations that might be due. Because technical, economic, and environmental-policy aspects must also be considered here, we will in the following investigate—for an industrial power plant--what problems might spring from a conversion to fluidized-bed-fired coal boilers (Chapter 3).

2. State of the Art in Fluidized-Bed Furnaces

Fluidized-bed furnaces were used already 60 years ago in chemistry (14). It was further developed over the past 10 years for energy generation in various countries. During that span of time, about 30-40 widely differing systems were built with the

use of fluidized-bed furnaces. The more recent technical developments in fluidized-bed furnaces were disseminated from Great Britain to the United States, the FRG, as well as Sweden and Finland.

Research and development work is essentially aimed at making the following two fluidized-bed furnace development lines ready for the market:

1. Fluidized-bed furnaces operating under standard pressure and

2. Fluidized-bed furnaces operating under high pressure.

Research on atmospheric fluidized-bed furnaces advanced most of all. But commercial utilization so far can be found only in the output range around 3 Mw, primarily in England. Among the plants built so far, the authors consider those at Rivesville, United States, Renfrew, UK, and Flingern, FRG, to be the most importnat.

The Rivesville plant generates a thermal output of 100 Mw and is connected to a 30 Mw turboset. It was financed by the Department of Energy and was built by the boiler firm of Pope, Evans, and Robbins and Foster Wheeler as demonstration plant. Operations began in the summer of 1976. The boiler is considered one of the first whose design was determined by the fluidized-bed technology (4). It has four fluidized-bed segments in a vertical arrangement, one of which serves as a special afterburning unit for flue ash which still contains about 15 percent carbon. When all of these cells [units] are working, the final combustion is 70-83 percent and if only one cell is working, it is 89-93 percent. Desulfurization of more than 90 percent with simultaneously very low NO_x emissions would be proven repeatedly. A better final combustion rate is to be achieved through rebuilding or new construction (8).

The system at Renfrew, Scotland, is considerably smaller; it has a thermal output of 16 Mw and was made by Babcock Combustion Systems Ltd. After the start of operations in 1976, the plant at the end of 1977 already had a running time of about 5,000 hours (11). Here again the boiler efficiency is somewhat low with about 80 percent. But it must be kept in mind that Renfrew involved the conversion of an old moving-grate boiler and that the efficiency is supposed to turn out better for new structures and improved plants. Here again, desulfurization of more than 90 percent was established through addition of limestone. While the Rivesville plant had a special afterburning cell for carbon-containing flue ash from the other cells, the flue ash in Renfrew can be returned into the basic bed consisting of three sections. By turning off various sections and fields, it is possible to operate a partial load of 25 percent of maximum load.

The biggest fluidized-bed plant operating in the FRG is in Duesseldorf-Flingern and is connected to a community thermal power plant. The system attains a thermal output of 35 Mw. It is operated by Ruhrkohle AG or its affiliate GVV (Gasification and Liquefaction, Inc.) and was built by Deutsche Babcock Group. The plant is considered a demonstration and research facility; the Federal Ministry of Research and Technology took care of 60 percent of the total planning costs in the amount of DM18 million (9). Various programs have been run since the summer of 1979 in order to arrive at additional knowledge regarding the performance of the fluidized beds. Desulfurization of more than 90 percent was proven, whereby the

limestone variety used did influence the particular results. The full combustion rate according to the manufacturer is just about 90 percent and improvements are possible.

Finally we might mention the 25 Mw fluidized-bed plant in Enkoping, Sweden, which was built by the Finnish Firm of Kymi Kymmene in Heinola, Finland. The plant however is used mostly to burn wood, oil, and gas waste (3, 6).

The second line of development--fluidized-bed furnaces under pressure--has been implemented only in a few systems so far. The essential advantage of pressure-operated fluidized-bed surfaces resides in the considerable reduction of the structural size so that there is a chance for capital cost reduction. During operation under pressure, it is necessary to use a gas turbine to relieve the pressure fro the combustion gases and desirable side effect here is the increase in the overall efficiency. The experimental plant at the Haniel Shaft Plant in Bottrop and the experimental plant of the IEA in Grimethorpe, Great Britain, are important research projects which are either in the planning stage or under construction.

The Bottrop plant in supposed to have a thermal output of 25 Mw at a pressure of 4.5 bars. The connected Sulzer gas turbine is supposed to generate 3.5 Mw of electrical current along the way. The plant is being designed by AGW (Fluidized-Bed Furnace Working Group), an outfit founded by Bergbauforschung GmbH and Vereinigte Kesselwerke AG and is being built in cooperation with STEAG AG [Hard-Coal Electricity Corporation] (13). The Grimethorpe plant reportedly comes up with a thermal output of 80 Mw at a pressure of 10 bars. The system works for a power plant with an electrical output of 600 Mw and six pressure-operated fluidized-bed chambers. It is being financed as a joint undertaking by the Federal Ministry of Research and Technology, the Department of Energy and the National Coal Board (10).

In addition to the previously mentioned plants at Flingern and Bottrop, other systems are under construction or are being planned for the use of fluidized-bed furnaces in the FRG (10). The lessons learned at Flingern showed that the fluidized-bed technology is ready for commercial use.

Two case studies were investigated at the ISP in Hanover on a contract for Ruhrkohle AG to determine the chances of fluidized-bed furnaces from the economic viewpoint. Both case studies were prepared in cooperation with KWU AG and with the support of Vereinigte Kesselwerke, the Hanover Municipal Works, and the Hannover-Stoecken Volkswagen Factory. The results of the case studies will be described below and they relate to the Hanover-Stoecken Volkswagen Factory and the Hanover-Muehlenberg residential area with adjoining industrial enterpriese.

3. VW-Stoecken Industrial Thermal Power Plant as Model Case

3.1. Current Energy Consumption and Energy Output

The VW factory in Hanover-Stoecken is a pure motor vehicle production plant which is located in the northwestern part of Hanover on a compact piece of land covering about 1 km^2. In 1978, the factory employed about 1,800 workers. The factory has its own oil-fired thermal power plant and gets additional current and gas from the Hanover Municipal Works.

Table 1 presents an overview of in-house current and heat generation in recent years.

Table 1. Long-Term Current and Heat Generation at Existing Thermal Power Plant

		1977	1978	Maximum (1970 bis 1978)	Minimum (1970 bis 1978)
Strom 1)	GWh	136	154	185	130
Raumwärme (unter 130 °C) 2)	GWh	154	182	220	150
technische Wärme (bis 160 °C) 3)	GWh	200	210	290	198

Key: 1--Current; 2--Space heat (below 130° C); 3--Industrial heat (up to 160° C); 4--To.

The ratio between current and heat generation thus was 1:1.47 in 1977 and 1:1.36 in 1978. Looking at the annual current and heat output in 1970-1978, we can see that the current and heat generation fluctuations run mostly parallel. The load requirements for the boilers are extensively determined by the particular heat requirement; nevertheless, in studying the load we must consider not only the heat requirements but also current generation because a current output corresponding to the heat output is not being produced at all times.

Figure 1 presents an overview of the entire energy flow situation at the VW factory.

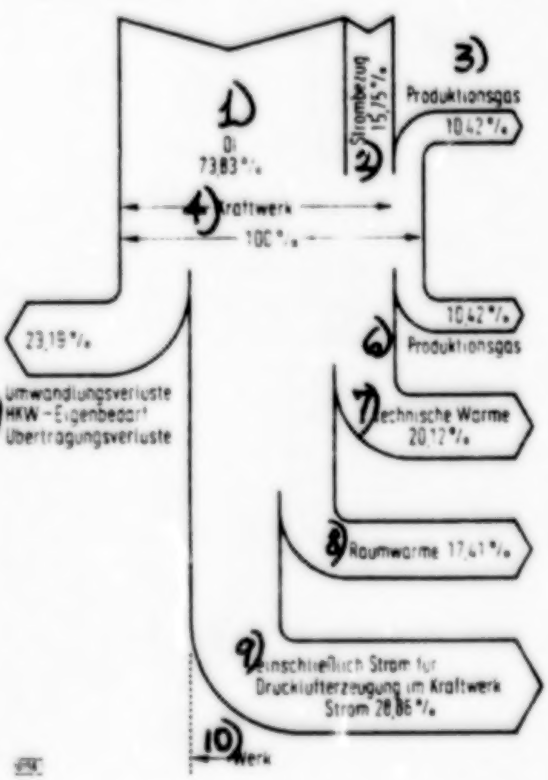


Figure 1. Energy flow chart at the Hanover plant of Volkswagenwerk AG. Key: 1--Oil; 2--Current procurement [consumption]; 3--Production [output] gas; 4--Power plant; 5--Conversion losses, in-house requirements of thermal power plant, transmission losses; 6--Production [output] gas; 7--Industrial heat; 8--Space heat; 9--Including current for compressed-air generation in power plant, current 28.86 percent; 10--Factory.

3.2. Data on Load Performance

Looking at the time curve for the current and heat requirements in greater detail, we find:

Major fluctuations in seasonal terms,

Fluctuations, typical of industrial enterprises, within one work week, and

Fluctuations within one work day and on weekends.

The consideration of the load structure is therefore very important because we must first of all find out whether the anticipated fluidized-bed boilers will also be able to meet the particular load requirements. Regarding heat requirement and current generation, we have the following seasonal load fluctuations which are illustrated by way of example for three typical days in Table 2.

The minimum and maximum values given for the heat requirement cover a sector which one must hardly exceed or fall short of due to temperature conditions.

Table 2. Heat Requirement and Current Generation of Stoecken VW Factory on Work Days in the Summer during Transition Times and in Winter, Given in Mw

Datum 1)	4. January 1979	26. März 1979 3)	22. August 1979
Außentemperatur (Min/Max) 2)	–15 °C/–11 °C	7 °C/15 °C	16 °C/26 °C
Wärme-Maximallast 4)	158,2	67,5	23,3
Wärme-Minimallast 5)	139,7	45,4	9,3
Strom-Maximallast 6)	64	65	58
Strom-Minimallast 7)	34	23	29

Key: 1--Date; 2--Outside temperature; 3--March; 4--Maximum heat load; 5--Minimum heat load; 6--Maximum current load; 7--Minimum current load.

In addition to the seasonal fluctuations, we also have considerable load changes throughout a week which are caused by the fact that there is no work being done on weekends. Table 3 tells us the story.

Table 3. Load Fluctuations within One Week

		1) Sommerwoche 1979		2) Winterwoche 1979	
		Max	Min	Max	Min
Wärme 3)	MW	31	7	158	101
Strom 4)	MW	65	12	48	14

Key: 1--1979 summer week; 2--1979 winter week; 3--Heat; 4--Current.

The daily heat requirement load fluctuations are relatively minor. The daily current load fluctuations are reproduced by way of example in Figure 2.

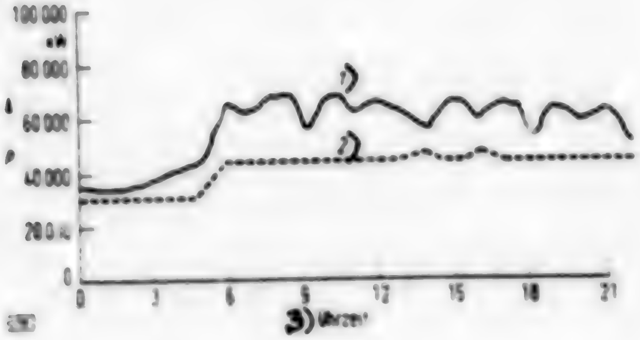


Figure 2   Current requirement and in-house production at the Hanover-Stoecken VW Factory. Thursday, 4 January 1979, average outside temperature about -13° C; 1--Total; 2--In-house production; 3--Clock time.

If one were to assume complete in-house current supply for the fluidized-bed boilers, then, in the extreme case, we would have to be able to run a load range from about 21 Mw all the way to about 232 Mw (thermal). If, for the fluidized-bed furnace, we select three equally large boilers which, because of the way they are segmented, can be run at a partial load of about 20 percent, then we get a load range which starts at 6.7 percent of full load, that is to say 16 Mw (thermal), and which thus covers the above-mentioned spread.

Because of the partly very rapid changes in output requirements and the relatively high current requirements, it does not seem to make sense to try for full coverage of the current requirements in spite of the above-sketeched possibilities. In converting the power plant to fluidized-bed furnace operations we therefore start with the maintenance of the current generation output so far, so that, during individual time intervals, we will get a more favorable load curve for the boilers than the one indicated above.

3.3. Current Energy Consumption Coverage

The thermal power plant was built in 1955-1965 and was run on heavy fuel oil. The total of seven boilers produced a steam output of 375 t/hr. Some of the steam can be used via eight turbines for current generation. The maximum electrical output of the eight turbines is 48 Mw. The turbines are seven counterpressure or counter-pressure-removal turbines and one condensation turbine. The steam for industrial heat and space heat is taken from the tapping turbines. The number of turbines and boilers is not given by the partial load requirements but rather by long-term development in the past. The way the power plant is run depends on the particular heat requirements. As much current as possible is obtained here, to the extent that the current can be taken out in the plant or to the extent that in-house current generation is cheaper than procurement from the public grid. Concerning the degree of in-house supply, no requirements have been set up by the public current supplier who meets the particular residual requirements or, in the summer, the total requirements.

3.4. Hypothetical Coverage of Energy Consumption by Means of Fluidized-Bed Boilers

In converting the oil boilers to fluidized-bed boilers, we assume that the fluidized-bed-fired plants will supply the same turbine group as is the case now. In place of

the six boilers for heavy fuel oil, we would have three boilers with fluidized-bed furnaces. For this purpose, VKW (United Boiler Works) AG [Inc.] worked out a rough design whose technical concept is summarized in Table 4. Table 3 shows the size ratios for the boiler house and the coaling plant.

Table 4. Technical Data of Fluidized-Bed Boilers for Stoecken VW Thermal Power Plant

Fuel charging		
Fuel pipe	Hard coal	
Caloric value H_u	5,000	kcal/kg
	20,930	kJ/kg
Water content	4.6	%
Ash content	to 45.0	%
Sulfur content	0.8	%
Approximate grain size	10	mm
Fuel processing		
Grain size range	0 to 6	mm
Residual humidity	3	%
Fluidized-bed furnace plant		
Data per unit:		
Type AWSF		
Fuel quantity	5.6	kg
Combustion air temperature	210	°C
Air surplus coefficient	1.2	
Flue gas volume	56.5	kg/s
Fluidized-bed temperature	850	°C
Fluidized-bed speed	2.0	m/sec
Fluidized-bed surface	72	m^2
Fluidized-bed height	1.2	m
Number of cells	6	
Steam generator		
Data per unit		
Type VKW natural circulation boiler		
Steam volume	140	t/hr
Licensing pressure (absolute)	95	bar
Hot-steam outlet pressure (absolute)	74	bar
Hot-steam temperature	530	°C
Feed water temperature	160	°C
Hot-steam temperature constant as of load	60	%
Waste gas temperature	160	°C
Air temperature after pipe air preheater	210	°C
Flue gas evacuation		
Pure gas dust content	100	mg/Nm^3 tr.
Related to an O_2 content of flue gases amounting to 6%		
N—standard		

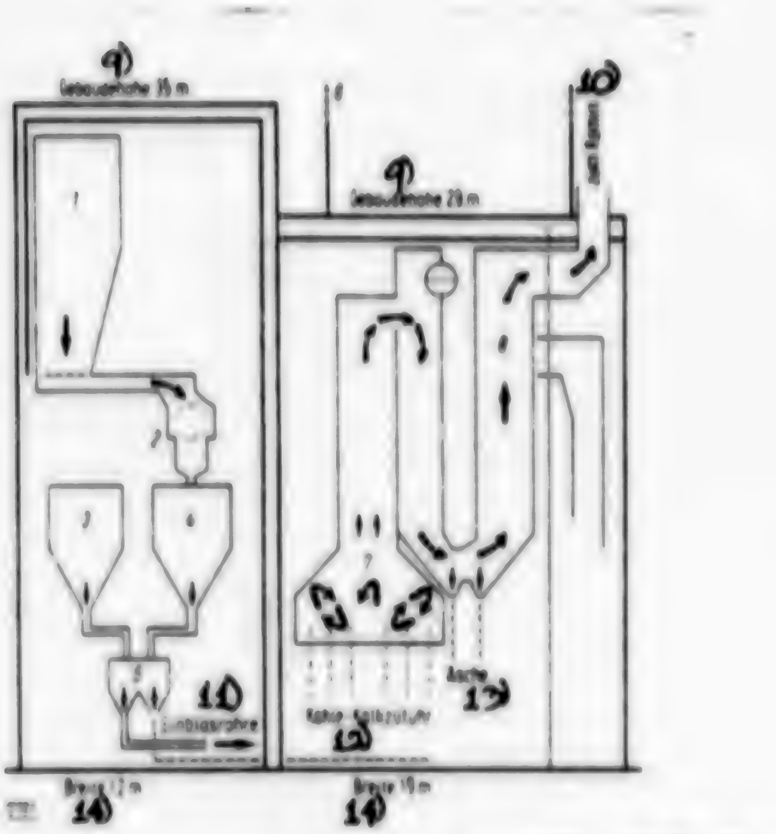


Figure 3. Diagram illustrating fluidized-bed boilers and coaling plant.
Key: 1--Daytime bunker; 2--Impact-crusher grinding plant; 3--Lime bunker; 4--Coal bunker; 5--Mixer; 6--Dome for fabric filters, height 19 m; 7--Fluidized-bed chamber; 8--Flue-gas outlet; 9--Building height; 10--To chimney; 11--Injection pipes; 12--Coal-lime supply; 13--Ash; 14--Width.

The total conversion costs have been estimated at DM62 million (excluding VAT) by VKW. An additional estimate of DM4 million has been given for the raw coal storage area.

3.5. Fuel Cost Comparison

In 1978, the power plant used up 67,700 t heavy fuel oil. The authors assume that, starting in 1980, 70,000 t will be needed each year. On the basis of the allowance for ballast coal, which is difficult to sell, a coal grade with 40-45 percent ballast is used for charging. The thermal power plant accordingly would need about 165,000 t of coal with a ballast content of 45 percent.

In April 1980, the price tag for heavy fuel oil was about DM300 per ton, excluding VAT and including transportation costs and storage fees. Looking at the scenarios for future oil price development, a price of DM300 per ton in 1980 was therefore used as basis, so that the 1980 fuel costs would come to DM21 million. Furthermore, an annual average inflation rate of 4.5 percent was assumed, plus an additional 5 percent or 7 percent real oil price rise. This corresponds to 9.73 percent or 11.82 percent nominal price rise.

According to the RAG [Ruhrkohle AG] price list applicable in April 1980, the price for one ton of 45-percent ballast coal would be DM81.88 so that, with shipping costs of DM24/t, the total 1980 fuel costs would come to DM17.47 million. For the annual coal price rises (including shipping costs) we likewise estimated an inflation rate of 4.5 percent. It is assumed that this rate will go up by one-third of the real oil price rise rates. That would give us nominal coal price rises of 6.24 percent per year or 6.94 percent per year. The real price rise for coal (which is above the general inflation level) is due, on the one hand, to the makeup requirement on coal prices and, on the other hand, the rising price difference between coal and oil.

If we now figure the differences for the energy utilization costs from both types of furnaces, we find that coal already today is about 17 percent more favorable than heavy fuel oil. The situation for the power plant operator is even further improved in case of a coal furnace if the subsidies according to the Third Law on the Use of Coal for Electric Power Generation are considered. Among the three possible subsidy categories, we must consider the additional enterprise operating cost subsidy M and the ballast coal subsidy. Because the heat price difference W has already become negative due to rising oil prices, there is no subsidy here.

The additional enterprise operating cost subsidy M comes to DM4.77 million according to the formula for power plants with more than 30 Mw and on up to 250 Mw:

$$M_c = A_c \times (0.308 + 0.009 \cdot \frac{3 \times n}{n + 2}) + 536600 + 14.25 \times B$$

Here, A represents the procurement and manufacturing costs of the power plant amounting to DM66 million. Even if--looking at the assumed boiler enlargement to 420 t/hr of steam (same fresh-steam state) we only give the present-day value of 358 t/hr for the eight turbines, this would still be more than 80-percent figure required in the Third Law on Current Generation from Coal. The factor n mathematically turns out to be about 2.27. In order to be on the safe side in our subsidy computation, we estimate here only n = 2. The magnitude B gives us the fuel quantity in tons of SKG [hard coal units] and in our case here happens to be 98,000 t SKE.

The ballast coal subsidy, in case of 45 percent ballast share, is DM47.46 per ton of SKE. In order here again to be on the safe side, we estimate a ballast coal subsidy of DM43/t SKE so that we get a subsidy amount of DM4.21 million per year.

The gross fuel costs for coal furnaces thus go down by DM8.98 million per year, that is to say, the fuel cost advantage deriving from coal goes up to DM12.5 million due to these subsidies already in 1980. But from that one cannot conclude that conversion from fuel oil to coal is worthwhile because higher capital costs must be accepted for conversion.

The comparatively low quantities of limestone for desulfurization could be delivered by rail. We assume that the limestone costs will be balanced out with the proceeds from the ash which can be sold as heat-insulating construction material.

3.6. Capital Costs

In our consideration of the capital costs we assume that we might be in a position to choose among two types of furnaces in 1980. In 1980, the oil boilders have a replacement value of DM5.31 million.

For the capital costs, we assume 3 percent real interest and for the inflation rate we assume 4.5 percent annually. Furthermore, we start with a linear depreciation of 4 percent per year, that is to say, a plant lifetime of 25 years. For the oil furnace we then get annual capital costs amounting to DM0.62 million. For fluidized-bed furnaces with a production price amounting to DM66 million, we estimate depreciation amounting to 2.64 millions per year (4 percent linear). In looking at the capital costs, the authors assume that the investment subsidy, based on the investment promotion law, will be paid out in the amount of 7.5, plus an additional investment cost subsidy amounting to 35 percent according to the program for future investments (due to expire on 31 December 1980 although it will probably be extended). Furthermore, we also consider an investment subsidy based on the Third Current Generation Law for Newly Installed Capacity from Coal-Fired Power Plants amounting to DM80/kw. With an output of 45 Mw, we thus get a total subsidy of DM8.64 million. If we deduct the subsidies from the market price of DM66 million, then we find that VW will have to handle an investment volume of DM29.31 million. That results in a capital service of DM2.24 million per year. Together with the depreciation we thus get total annual capital costs amounting to DM4.88 million, as against DM0.62 million for oil furnaces. The additional annual capital costs for fluidized-bed furnaces, compared to the oil furnaces installed at VW, thus amount to DM4.26 million.

The resultant annual cost advantage deriving from fluidized-bed furnaces is given in Table 5 for the above-mentioned oil price scenario. Table 5 shows that the coal furnace in all cases investigated is considerably cheaper than the oil furnace. The cumulative cost advantages exceed the current replacement value of the oil furnace already after 2 years and that oil furnace would have to be scrapped and would thus have to be written off at a zero figure.

Table 5. Cost Advantage from Fluidized-Bed Furnace, Given in Millions of DM at Current Prices in the Following Years

Jahr 1)	2) nominale Ölpreissteigerung 9,725 % 3) nominale Kohlepreissteigerung 6,24 %	4) nominale Ölpreissteigerung 11,815 % 5) nominale Kohlepreissteigerung 6,94 %
1980	8,25	8,25
1981	9,20	9,32
1982	10,28	11,01
1983	11,51	12,72
1984	12,90	15,70
1985	14,47	16,99
1986	16,24	19,63
1987	18,24	22,67
1988	20,48	26,15
1989	23,00	30,13
1990	25,83	34,70
1991	29,01	39,91
1992	32,55	45,86
1993	36,52	52,62
1994	40,94	60,32
1995	45,89	69,06

Key: 1--Year; 2--Nominal oil price rise 9.725%; 3--Nominal coal price rise 6.24%; 4--Nominal oil price rise 11.815%; 5--Nominal coal price rise; 6.94%.

3.7. Comparison of Environmental Pollution and Transportation Volume

Because no changes are to be made in the chimney heights for both types of furnaces, we need to compare here only the emission values for the differing types of furnaces.

The following emission values, related to each cubic meter (m^3 in the normal state) of waste gas were used as basis:

	Oil furnace	Fluidized-bed furnace
SO_2	1.8 g/m^3	0.85 g/m^3
Dust	13 mg/m^3	20 mg/m^3

The emission values per cubic meter used as basis were derived for the oil furnace from the continuing measurements made by the Stoecken VW thermal power plant and for the fluidized bed they were derived from the trial operation of the Duesseldorf-Flingern Thermal Plant.

The following flue gas volume resulted in connection with the oil and coal consumption volume:

70,000 t fuel oil S ≙ 798 x 10^6 m^3 flue gas
165,000 t ballast coal (45%) ≙ 912 x 10^6 m^3 flue gas.

These waste gas volumes contain the following harmful substances in accordance with the predetermined emission figures:

	Oil furnace	Fluidized-bed furance
So_2	1,436 t	775 t
Dust	10.4 t	18.2 t

The emissions of SO_2 in the case of the fluidized-bed furnace comes to only about 50% of the oil furnace figures. Here, the figures measured in Flingern correspond only to a desulfurization degree of 68-72 percent. Because this value can still be improved up to 90 percent desulfurization, the SO_2 emissions can still be considerably reduced.

The dust emissions from fluidized-bed furnaces go up by about 80 percent. Because the dust volumes however are comparatively small (most of the dust is retained in the fabric filter), this decline in emission values is not particularly grave. The quantitative input goes up in case of conversion from oil furnace to fluidized bed from 70,000 t to 165,000 t. In addition we have the lime charge of about 13,000 t. This means that the total input weight connected with conversion to fluidized-bed furnaces went up by 154 percent compared to oil furnaces, in terms of weight. The conversion to ballast coal here obviously entails a disadvantage in handling. The combustion residues constitute another problem.

While in the case of the oil furnace, we have practically no combustion residues, we do get ash amounting to about 87,000 tons per year when we use ballast coal and lime. Because the extremely fine-grained nature of this ash [illegible] lead to

difficulties in dumping and because the ash volumes developing will also cause high transportation or dumping costs, one must absolutely try to use the ash as construction material or construction material additive. Corresponding experiments concerning the production of bricks, mortar binders, and light-weight concrete additives produced promising results so that the reuse of the residues does seem possible (7). Even dumping costs of DM10/t could reduce the positive cost difference of the fluidized-bed method shown in Table 5 by about DM1 million --although they do not make the entire method uneconomical.

4. Muehlenberg Thermal Power Plant

4.1. Muehlenberg-Bornum Residential and Industrial Region

At the southwestern edge of the city of Hanover we find the industrial region of Bornum and the satellite city of Muehlenberg, which by the middle of the eighties will have about 15,000 inhabitants and can thus be considered typical of many such solutions in metropolitan areas. The distance to downtown Hanover is about 8 km so that interconnection with the Hanover long-distance heat network is relatively simply (1).

Residential housing, put up exclusively over the past 20 years, at the end of 1979 included about 2,200 apartments and 230 row houses and detached homes. Currently, about 70 percent natural gas and about 30 percent light fuel oil are being used for heating and hot water. Electrical night-time storage heating units are so rare that they can be neglected. The data on energy consumption for hot water and heating were collected by means of a survey covering about 84 percent of all units.

In the industrial area, which is on both sides of the Linden freight station, the Hanomag Construction Machinery Company is the biggest complex. The energy supply for the tradition-rich Hanoveranian outfit is made up of a large number of different individual solutions because of the way the structures grew over the years. Most of the heat supply comes from decentralized gas-heating plants and hot-water plants as well as a small thermal power plant with a 4-Mw counterpressure turbine whose boilers are operated with gas and, during special peak hours, also with coal. The company's heating network is designed for steam (220° C, 4 bars), something which must be taken into consideration in case of supply from a new thermal power plant.

The load curve for heat extraction was estimated both in the residential area and in the industrial area (Figure 6). In practical terms it differs only little from other load curves which are used in the long-distance heat industry.

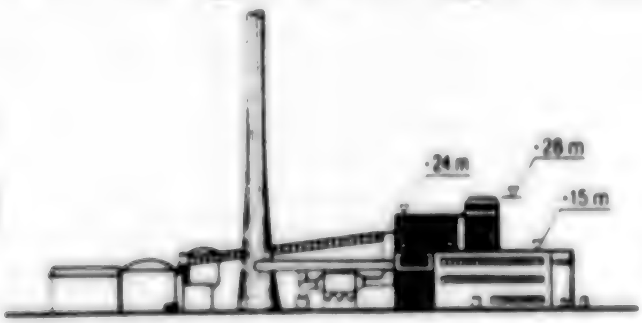


Figure 4. Muehlenberg model thermal power plant, side view.

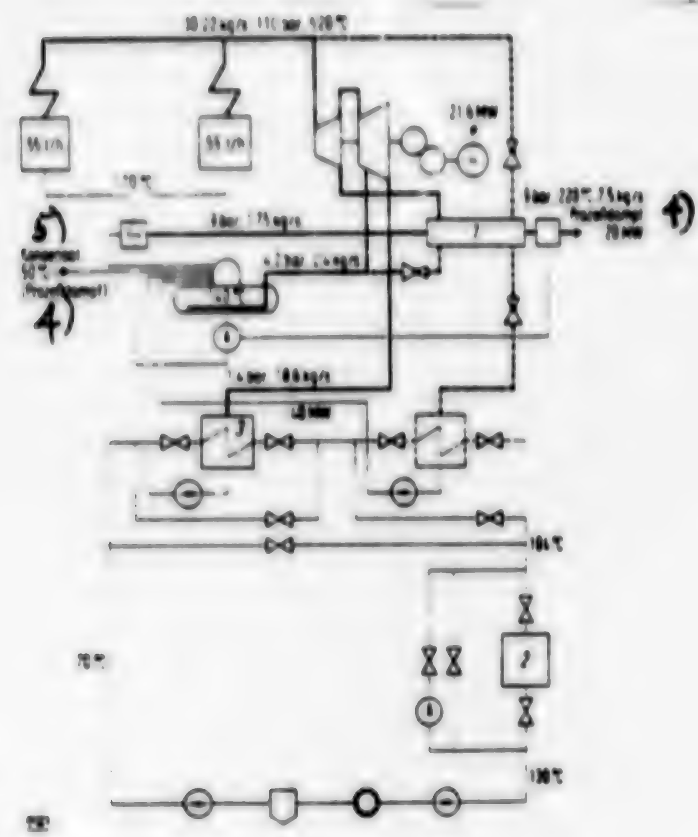
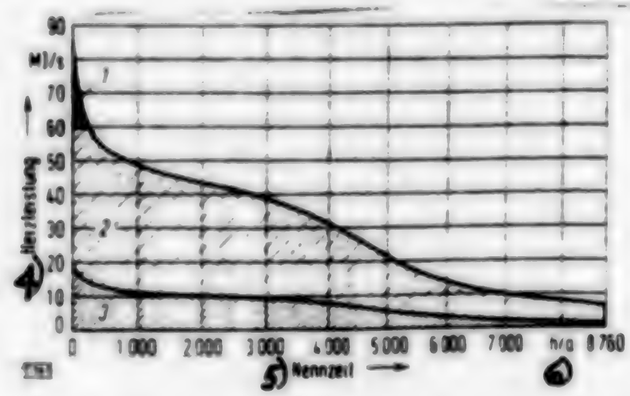


Figure 5. Block diagram of Hanover-Muehlenberg model power plant. Key: 1--9-bar distributor; 2--30-Mw heating water boilers for peak and reserve load coverage; 3--Heating condenser; 4--Processed steam; 5--Condensate.



gure 6. Arranged annual load curve of heating water and hot-steam consumption n the Mueblenberg residential and industrial areas. Key: 1--Peak load; 2--Heating water; 3--Heating steam; 4--Heat output; 5--Nominal time; 6--Hours per year.

4.2. Present-Day Heat Supply Costs

As reasonable prices for long-distance heat supply one could propose at most those values which heat consumers must cope with as costs if they retain their present-day heating and hot-water systems. The costs for the case investigated here are

made up of the heat costs of the industrial area, the already built-up section of the residential area, and the construction activities which are to take place over the next 5 years. Table 6 shows the total costs.

Table 6. Heat Requirement of Muehlenberg Residential Area and Bornum-Muehlenberg Industrial Area Suitable for Long-Distance Heat Supply (Including Expansion of Muehlenberg-South Residential Area)

Energy used		
At consumer's end	about 700 TJ	
Fuel used	852 TJ	
Fuel costs	gas: 200 GWh	DM 6.8 million (1)
1980 price level	oil: 31 GWh	DM 1.6 million
	coal: 658 t	DM 0.1 million
Operating costs		
Depreciation for burners, tanks, etc.		DM1.0 million
Heat costs (spring 1980 price level)		DM9.5 million

(1)--It was assumed here that the entire additional new construction projects in the Muehlenberg-South residential area would be supplied with gas.

4.3. Heat Supply by Means of Long-Distance Heat from Thermal Power Plant

The total costs of long-distance heat free at the consumer's end are made up as follows (see bibliographic reference 2, pp 123 ff):

Heat generation costs: here we have not only the technically determined value for fuel use, capital costs, but also current-industry evaluations and start-up costs with surplus capacities;

Long-distance heat transport costs which overwhelmingly represent capital costs for the far-flung long-distance line network, including all costs for subdistribution and costs of delivery to consumers;

Cost of converting existing systems made up of special depreciation and technically required conversion.

Because of the relatively dense buildup pattern of the residential area and the concentration of heat delivery to just a few big industrial consumers, the long-distance heat network can be built rather at low cost. Using data supplied by the Hanover municipal works on network construction costs, we get the estimate of the investment volume for a long-distance network as shown in Table 7. The site for the thermal power plant was assumed to be an area with a rail connection [siding] in the area of the industrial park.

Table 7. Estimates of Costs of Long-Distance Heat Distribution Network for Muehlenberg Thermal Power Plant

Already built-up part of residential area	
3,800 m main distribution lines (from power plant)	DM 4.0 million
4,500 m subdistribution lines (including 12.5% safety subsidy)	DM4.2 million
Home connections (3 large, 33 medium, 228 small)	DM2.2 million
Industrial park connection	DM2.6 million
(including additional equipment for industrial enterprises, DM0.3 million)	
Muehlengerg-South new development area	DM10.0 million
Subtotal (1979 price level)	DM23.0 million
Conversion to 1980 spring price level	
(x 1.085, that is to say, addition of 8.5 percent)	+ DM2.0 million
Total costs (spring 1980 price level)	DM25.0 million

This pure investment volume of the long-distance heat network must naturally be increased by the rate of inflation and the interest costs in a dynamic capital value study over the period of construction.

The investment volume for the thermal power plant depends essentially on the design. Because a thermal power plant would have to be operated by the Hanover Municipal Works, it will be necessary to build the thermal power plant as a counterpressure system based on the current management situation at that enterprise. Under different general current management conditions, it must also be interesting to look into a removal-condensation plant or a tapping plant with somewhat higher investment costs per kilowatt installed. But that is a question of designing the turbine set, not the boilers.

The thermal power plant construction costs were determined by KWU and VKW considering the specific costs of a boiler plant with fluidized-bed furnace. The outward appearance of the thermal power plant is shown in Figure 4.

The simplified heat-engineering circuit diagram is illustrated in Figure 5. The values entered apply to the peak load case, that is to say, when we have a power-heat combination, we can give off about 20 Mw (thermal) via uncoupled process steam and about 40 Mw (thermal) via heating water. Here we get an electrical output of about 22 Mw. The rest of the heating water is heated up through the heavy-oil-fired or gas-fired heating water boiler (30 Mw).

With a heat output of less 60 Mw (thermal), the heat requirement can be met through the power-heat combination alone. That would amount to about 98 percent of the total annual work, as we can see from Figure 6. The turbine's counterpressure can be raised to about 1.7 bar, which enables us to attain a lead-in temperature of about 100° C by means of the heat condenser alone.

At base load, the heating water is heated in one phase through the heat condenser. Assuming a sliding lead-in and return-run temperature, depending upon the outside temperature, the peak-load heating water boiler will have to be connected in

likewise at an outside temperature of less than about 9° C. As the heating output goes up, the separation temperature between heating condenser and heating water boiler will then be shifted up to the boundary value illustrated in the block diagram in Figure 5.

The investment volume results as illustrated in Table 8 for the thermal power plant, including the long-distance heat network.

It is presently possible to request government aid to a considerable extent as subsidies for the investment volume involved in a thermal power plant. Without this kind of support, it would be very difficult for many urban power plants to assume the risks of increased long-distance heat expansion and the financing burden. Within the context of the program for future investments, it is possible to subsidize up to 35 percent of the construction costs. In addition, the usual investment allowances are granted in the amount of 7.5 percent. According to the Third Current Generation Law, DM180/kw of installed electric output are paid as subsidy for coal-fired power plants.

Table 8. Total Investment Volume for Muehlenberg Power Plant

Thermal power plant part without steam generator		DM50.6 million
Including: planning, construction management, etc.	DM3.5 million	
construction part	DM20.7 million	
mechanical and engineering part	DM20.4 million	
electrotechnical part	DM6.0 million	
Fluidized-bed boiler plant		DM19.1 million
Long-distance heat network		DM25.0 million
Land, railroad siding, minor miscellaneous investments		DM 5.3 million
Total investments for thermal power plant		DM100.0 million

If we figure the land at a cost of DM1.0 million, we thus get subsidies amounting to DM46.1 million (42.5 percent subsidy for DM99.0 million + DM180/kw x 22,000 kw). As operators, the municipal works would thus have to come up with DM53.9 million on their own.

In order to be able to compare the heating costs of the old supply system for the residential and industrial areas to the potential costs of a long-distance heat supply network, it will be necessary, in the context of a long-term economic feasibility calculation, to investigate various possibilities of future energy price development in terms of their consequences.

4.4. Economic Feasibility Study for Muehlenberg Thermal Power Plant

The economic feasibility study for such a project must make certain assumptions regarding the future. The authors assume a uniform average inflation rate of 4.5 percent and a real interest of 3 percent, so that the standard interest rate would have to be estimated at 7.63 percent. The depreciation should come to 4 percent of the investment volume per year so that we start only with a 25-year lifetime.

The economic feasibility study to be sure will in the following be made for the municipal works as operators but, from the orders of magnitude determined, one can also very easily read off the dimensions of a cost-benefit analysis in the context of the national economy and interpret the situation accordingly.

The capital costs of the municipal works include the capital servicing (7.63 percent of DM53.9 million) and the depreciation (4 percent of DM99 million) so that they come to a total of DM8.04 million. The neglect of the capital costs of the subsidies can be explained in terms of the national economy by making reference to higher energy-policy objectives.

The operating costs consist of the fuel costs, the personnel costs, and other costs. The fuel use comes to 1,500 TJ (about 50,800 t SKE) in the form of ballast coal (45 percent ballast) according to the April 1980 RAG price list costs about DM9.8 million per year. As a result of operating cost subsidies based on the Third Law on Coal Use for Current Generation (Subsidy M = DM2.66 million) and ballast coal subsidies (DM1.92 million), the municipal works face net fuel costs amounting to DM5.2 million.

The personnel costs cover 45 workers, including 20 in the shift operation of the technical sectors. Estimating an average of DM60,000 per worker and per year, the annual personnel costs come to DM2.7 million.

Additional costs for taxes, insurance, long-distance heat computation, etc., can be estimated at around DM2.0 million. The total costs thus turn out to be DM17.94 million, as summarized in Table 9.

Table 9. Annual Total Costs for Muehlenberg Thermal Power Plant (Spring 1980 Price Level)

Net fuel costs	DM5.20 million
Personnel costs	DM2.70 million
Miscellaneous costs	DM2.00 million
Capital costs	DM8.04 million
Total annual costs	DM17.94 million

The annual total costs must be carried over for the future in the individual components. Because, looking at the capital costs, we are already considering an inflation allowance in the interest rate, those costs remain constant. The personnel costs will go up at least along with the rate of inflation and so will the other costs. The net fuel costs on the one hand depend on the price policy of the coal producers as compared to other primary energy sources and on the other hand it is especially the government subsidies which influence the actual cost burden on the municipal works. For the government coal subsidies it was assumed that they would remain fixed at a nominal level, that is to say, that in real terms they turn out to be worth less and less. Regarding coal price policy, several variations were computed as compared to oil and gas in order to get data which will hold water.

The thermal power plant's total annual costs for the coming 30 years must be compared to the potential earnings. These earnings result from the electric current

earnings and the long-distance heat earnings. In this connection, the following assumptions were made:

The construction time for the power plant and the long-distance heat network is 4 years; the investments are distributed over the years 1980-1983 at 25 percent, each;

The thermal power plant will start operating early in 1984;

As the price for 1 kwh of electric current, we estimated in each case 6, 7, 8, and 9 Pfennigs in 4 variations; the annual electric current volume was assumed to be 52.5 GWh (≙ 2,400 full-load hours); the current price was increased at an annual inflation rate of 4.5 percent so that, for example, in 1985 we figured on a kwh price of between 7.2 and 10.7 Pfennigs;

The maximum long-distance heat earnings which can be achieved are the same as the heating costs if we retain the present heating system; if an extremely great surplus should arise, then one must naturally abandon the assumption that the thermal power plant operator will fully utilize this maximum leeway to his own benefit.

In reality one would then have to expect a "distribution" of the entire national economic profit from the project over three groups: the city works as operators can make a profit even in case of a moderate price policy for long-distance heat; the consumers will save money through more favorable [cheaper] heat supply; and finally, coal price policy or government subsidy policy will probably also deviate during the nineties from the directions assumed here. It was assumed, as standard estimate for the coal price rises, that the real coal price rise rate would amount to one-third of the real oil price rise rate: at a general inflation rate of 4.5 percent and a real oil price rise of 5 percent, we get a nominal price rise rate of 9.7 percent for oil and 6.2 percent for coal. The thermal power plant's cash value determined below thus presents the present-day value of the project's national economic net benefit. If it is positive, then project should be built for reasons of the national economy. It is rather unrealistic to think that the total profit will indeed go to the operator: coal mining and consumers will be able to share in claiming this advantage only partly through the balancing mechanism which goes by the term of "coal and long-distance heat prices."

From the large number of economic feasibility computations made, Table 10 only shows the most important results.

Table 10. 1980 Muehlenberg Thermal Power Plant's Cash Values under Alternate Assumptions Regarding Real Oil and Gas Price Rises or Electric Current Prices

kWh-Preis 1)	a) P - Öl 2) [illegible] % b) P - Gas 5.6 %	a) P - Öl 2) [illegible] % b) P - Gas 7.6 %	a) P - Öl 2) [illegible] % b) P - Gas 9.7 %
6 Pf	12 Mio DM	—	—
7 Pf	22 Mio DM	97 Mio DM	216 Mio DM
8 Pf	—	105 Mio DM	225 Mio DM
9 Pf	—	114 Mio DM	233 Mio DM

Key: 1--kwh price; 2--Oil; P_f--Pfennigs; Mio--Millions.

The following reference case is considered here: real price rise rates for oil 5 percent and electrical current figure of 8 Pf/kwh. By way of summary we can say this: the Muehlenberg Thermal Power Plant is economical also in case of conservative assumptions regarding future oil and gas price rises.

As in the case of any thermal power plant project, the start-up phase is characterized by losses which however are made up in the reference case after 12 years. If there were to be no subsidies at all, this loss phase would definitely last longer. From this and from other computations made to check the situation out, we can see the need for promoting long-distance heat expansion also in the future through government subsidies or financing aides.

Until the year 1990, the gas price rise rate will be above the assumed oil price rise rate; the latter is based on the gap between the oil and gas price levels early in 1980 which presumably, according to announcements by the gas producers, is supposed to be eliminated in the coming years through gas price rises above and beyond proportion.

4.5. Comparison of Environmental Contamination through Harmful Substances

A thermal power plant generates heat and electric current. The total environmental pollution from the thermal power plant and the environmental contamination from individual furnaces (heat) and from conventional electric current generation must be compared to each other. For this purpose, we will use as basis the emissions of a coal-fired power plant without flue gas desulfurization with less than 350 Mw. For dust removal we assumed that 20 percent (30 mg/m^3) of the permissible maximum values in TA-air (150 mg/m^3) are attainable. All other emission values for electric current generation correspond to those of a medium-sized coal-fired power plant. Table 11 shows the comparison of emissions.

Table 11. Harmful Substance Emissions for Current Generation of 52.5 GWh in Medium Hard-Coal Power Plants, Individual Furnaces, and Heating Systems in Industry

	1) Stromerzeugung von 52,5 GWh	2) Wärme in Wohn- und Industriegebiet	3) Summe
Staub 4)	4900 kg	11606 kg	16506 kg
CO	10500 kg	1532 kg	12032 kg
CH_4	263 kg	820 kg	1083 kg
NO_x	114450 kg	51555 kg	166005 kg
SO_2	374850 kg	31663 kg	406513 kg

Key: 1--Electrical current generation of 52.5 GWh; 2--Heat in residential and industrial regions; 3--Sum; 4--Dust.

The emission values for dust and sulfur dioxide are very low because of the large percentage of gas furnaces. In computing the emission from the Muehlenberg Thermal Power Plant with its fluidized-bed furnace it was possible to fall back on measurements by the Flingern fluidized-bed heating plant in Dueseldorf. Because these emission figures were measured during trial operation, they represent preliminary values which presumably can be improved in the future. The figures used as a rule are roughly in the middle of the spread of emissions measured in Flingeren. Table 12 shows the total figures.

Table 12. Emissions from Muelenberg Thermal Power Plant

	Values from Flingern trial operation	Value used	Emissions from Muehlenberg HKW
Dust	10 to 30 mg/Nm^3	20 mg/Nm^3	9,530 kg
CO	Zero during normal operation	--	less than 100 kg
CH_x	No data	--	less than 300 kg
NO_x	30 to 50 ppm at 12% O_2 in waste gas	40 ppm	39,100 kg
SO_2	0.7 to 1 g/m^3 at CA/S = 2; Desulfurization 68-75 %	0.85 g/Nm^3	335 to 404 t depending on desulfurization

N = standard.

It is especially the values for SO_2 emissions which can still be considerably improved because desulfurization degrees of more than 90 percent were obtained in trial operation of smaller fluidized-bed boilers.

A comparison of the emission values gives us the following picture:

Dust emissions in the thermal power plant are about 40 percent below the status-quo values and this is true even although, on account of the high gas portion at Muehlenberg, excellent values were already achieved there. It would seem that this ratio would be definitely better in areas with a larger percentage of oil furnaces.

CO and NO_x values in the case of the Muehlenberg Thermal Power Plant are considerably below the values of energy supply so far. Here we noticed the high gas portion with NO_x emissions.

The SO_2 emissions are barely below the figures for the status quo conditions on account of the assumed desulfurization degree of 68-72 percent. A definite improvement however can be achieved here in case of additional experience with the fluidized-bed technique. In case of desulfurization of 85 percent, the SO_2 emissions would be cut in half.

4.6. Immissions for Muehlenberg Residential Area

The decisive factor in the acceptance of a thermal power plant in the vicinity of a residential development consists of the immissions, that is to say, the actual pollution to which inhabitants are exposed because of the harmful substances that reach them. Because nature alters the harmful substances emitted through dilution and self-cleaning, the distance between the power plant and the residential development, for example, the wind direction, and the chimney height play an important role. With its 150-m chimney, the thermal power plant would be sited about 1 km northeast of the residential development. If we assume a rather pesimistic dilution factor of 1:10, then the environmental pollution within the pure residential area--which so far comes primarily from the heating systems--would be definitely reduced.

In comparable residential areas with an even larger percentage of oil furnaces, one would have to estimate an advantage, deriving from a thermal power plant solution, amounting to 1:10 to 1:100 (the latter in the case of SO_2 and CO).

4.7. Ash Utilization

We get a large volume of ash due to the use of ballast-containing coal and the addition of limestone. With 45 percent ballast and 8 percent limestone addition, we are going to get more than 50,000 t of ash each year. But because this ash comes from a combustion process with temperatures below 800° C, it does not reach the melting point and comes in the form of a powder. Further use of this ash in the construction materials industry seems possible.

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COMMITTEE RECOMMENDS STEPS TO ADVANCE RESEARCH

Paris LE PROGRES TECHNIQUE in French No 18, 1980 pp 23-25

[Article on the guidelines of the report of the Research Committee chaired by Pierre Laffitte, director of the Ecole des Mines in Paris. The complete report has been published by DOCUMENTATION FRANCAISE: "Report of the Research Committee of the Eighth Plan"]

[Text] The Inescapable Imperative

The industrialized countries which have only limited resources of energy and raw materials could retain their position as a "rich country" only if their technological and scientific know-how allows them to assume the leadership in the international competition. This is the new rule of the game which France could not avoid.

French science and technology are good. However, is this not because, 10 years ago, our country was one of the industrialized countries making the biggest efforts? The decision taken by the government to provide a new impetus to French research will, unquestionably, strongly and justifiably affect the Eighth Plan.

The Eighth Plan Research Committee states firmly and unanimously that we want to, can, and must provide a very strong impetus to research. We must improve its effectiveness and better integrate it in national life.

Research does not consist exclusively of sensationalism, exploits, or the incomprehensible, reserved for the few initiated people, which prompts others to say somewhat suspiciously, "What else will they invent next!" Research affects all French people. Quality of life, living standards, employment or, briefly, daily life, are all dependent on it.

Our committee began by drafting a statement based on available data and on a very extensive individualized investigation in scientific and economic circles. It drew up a comparison with data of countries with similar capabilities: the FRG, the United States and Japan which, let us recall, are the only ones whose exports are superior to ours.

This statement and the occasionally heated yet always constructive discussions led the committee to draw certain clear conclusions.

It did not consider a quantified sectorial perspective, which is something done elsewhere, but the factors which determine the effectiveness and organization of our research, the opening of the organizations and their required departitioning, mobility of ideas and people, the sharing of knowledge and know-how, practical utilization, and regional or international problems.

Let us emphasize some converging attitudes despite the diversity of its membership.

There was a consensus in favor of developing a symbiosis among the four essential research sectors:

- Education (big schools and universities);
- Big public agencies;
- Collective research (technical and professional centers); and
- Enterprises.

Another consensus reached was that of not limiting the area of scientific employment to scientific progress alone but to consider that information and spreading of scientific and technical culture throughout society is a full-fledged scientific activity.

The suggested measures, repeated in the eight pages containing the report's conclusions, cover four groups of topics.

Mobilizing Means and Energies.

Greater financing is needed.

France spends 1.8 percent of its gross national product for research and development. We believe that by 1985 we should reach 2.3 percent. This is a considerable increase. Let us note that it is that of the FRG. Let us note that Japan, which spends 2 percent, is planning to raise it to 3 percent of its GNP.

In figures this corresponds to an increase (in constant francs) from 48 billion francs in 1980 to 70.4 billion francs in 1985, or a 22.4 billion franc increase (of which 7.2 from the planned increase of the GNP).

Or else, again, it represents an annual volume increase of 8 percent. In terms of employment, let us note that this rate in terms of the equivalent full time employment of researchers and research engineers, corresponds to an increase of 8,000 per year by 1985 for research done by the public, collective and enterprise sectors. It truly means a mobilization in pursuit of the priority target: the survival of our economic dynamism. We must be aware of the consequences in particular in terms of training the proper personnel.

The financing of this increase must be divided between the state and the enterprise sector. The committee believes that in the course of the Eighth Plan and taking the extent of this effort into consideration such increases must follow a parallel line.

The improvement of public research facilities and increased direct or indirect incentive for growth are indispensable and urgent.

The target of the public research institutions will be to insure the adequate renovation of personnel and raise operational funds to a level consistent with the available research personnel. This represents an increase of at least 50 percent of overall operational credits. The various institutions must be encouraged to set aside some of their facilities for the signing of contracts abroad.

The vigorous effort to carry out the necessary industrial research cannot be made without the encouragement of the state. A system of tax benefits must be organized and applied to any increase in research activities. It is suggested that the accounting and social balances must be completed by a research balance. The current incentive procedures must be developed, particularly aid to and bonuses for innovation. Contractural procedures such as programmed contracts, the combined activities of the Research Fund, and contracts concluded by the technical ministries appear to be particularly effective. It would be equally advantageous to study the possibility for a measure of automatic subsidy related to the hiring of researchers and the setting up of a professional fee for research laboratories. An initial aid for the dissemination of goods produced by new enterprises based on the practical utilization of research would favor the creation of such enterprises.

The state should establish a real industrial research observatory which will make rapid information regarding employment, expenditures, and implementation of projects by enterprises in scientific matters possible.

Regional research activities have recently been developed following the establishment of regional public institutions. Regional involvement leads to increased research incentive and encourages departitioning.

The regular development of regional activities, harmonized with national policy, would be very desirable. The regional research committees and the regional correspondents of the DGRST [General Delegation for Scientific and Technical Research] and the ANVAR [National Agency for the Valorization of Research] must develop information, implementation and valorization of research on the regional scale. Finally, it will be necessary to authorize the EPR to finance research operational expenditures other than personnel costs.

Rebalancing Research

A new balance must be achieved among the various components of national research. This could be achieved only by increasing national research expenditures and developing new forms of financing.

One of the priority targets is the rebalancing of research in the education sector. A very high proportion of the scientific and technical cadres, including those working in public or private research centers, are graduates of superior schools (80 percent in the case of industry).

Despite recent progress, particularly in some schools under the Ministry of Universities and Ministry of Industry and the Polytechnical School, research activities in these schools remains excessively weak. What makes this even more regrettable is that most research cadres are graduates of such schools. In order for the future cadres to meet the needs of an economy whose added value would include research and innovation to an ever greater extent, the means of the engineering schools must be improved and better ties must be established with university centers and public and private research institutions.

In the university field the committee dealt in particular with the liberal arts which suffer from a great shortage of means and, in particular, of research libraries. This sector, whose importance on the level of international cultural promotion is obvious, is also important on the economic level (tourism, publishing). Furthermore, the committee believes that the funds allocated to the Ministry of Universities and the Research Mission should be increased.

The structures and means of joint industrial research must be strengthened. This offers a better possibility for the dissemination of research results throughout industry and, particularly, among the small and medium industries. We must study the activities and ties among the various technical centers in terms of the specific features of the various professional areas. This may lead to restructuring which, however, would be successful only after increasing the means and strengthening the ties between research and the enterprises. A great increase in funds could be achieved partially by increasing the recearch budgets of enterprises and by signing more contracts between public agencies and technical and professional centers.

Scientific relations with developing countries must be improved. The political and economic stakes of better cooperation are sufficiently important to warrant the efforts to be made in the areas of information, training, aid and development of technologies adapted to the needs of our partners.

The commisssion ascribes particular attention to developing the evaluation of the research-innovation-valorization complex. Research must be evaluated differently for basic and finalized research. A common principle however, must apply: The judgment must be unrelated to the type of research. The setting up of commissions in charge of assessing valorization and transfer of knowledge capabilities, the development of auditing procedures, and the increased participation of foreign scientists must be promoted.

It would be equally proper to study the organization of an institution on anticipating the economic and social consequences of some scientific and technological choices. Its purpose would be to collect scientific and technical data to be put at the disposal of bigger organizations.

Elimination of Prejudices and Hindrances

There is too much of a tendency to present technology and science as mysterious and reserved domains. Everyone should be aware of the stakes of the success of our research and development system for all Frenchmen. To achieve this we must

engage in the extensive dissemination of scientific and technical knowledge, particularly among the young of school age. This target can be met only by expanding the use of science in the areas of dissemination, valorization, management and production.

The sensitizing of the various media to the development of scientific culture and the support of associations dedicated to this purpose, development of permanent training systems, exhibitions, and museums dedicated to science and technology are the means for influencing the public. We must also valorize the role of information within the scientific world itself.

All too frequently documentation and information activities are considered secondary scientific activities and their requests for financing reveals that they are considered sufficiently important.

Ninety-five percent of world research takes place outside of France. Frequently, it is more profitable to French research to gather, study, and disseminate information on current projects in foreign countries than promote work which has perhaps already been completed elsewhere in the world.

Documentation and information is a full-fledged scientific activity. It calls for emphasizing the need for funds for missions and stages of data gathering, auditing, and evaluation both in France and abroad. The scientists must be encouraged to participate in such missions. The role of the learned societies could be expanded in this area, for they are a privileged center for the dissemination of information.

Encouraging Mobility and Decompartmentalization

Our research system suffers from a major handicap: the lack of flexibility and adaptability caused by excessive compartmentalization. The transfer of knowledge and competence is poor. The various research establishments, public or private, draw up their programs without extensive concertation.

Exchanges of ideas and personnel among institutions are weak and almost nonexistent between the public and private sectors.

Finally, unlike the situation in other countries, the role of agencies and of contracts financed by the authorities or the private sector is not sufficiently developed. It is through contracts that the various individuals involved find out about one another.

Such decompartmentalization of structures and mobility of people and ideas are a fundamental factor for efficiency and the introduction of research in a society. The commission has formulated measures aimed at developing a state of mind which would facilitate voluntary decompartmentalization and mobility, for society cannot be changed by decree.

Thus, it would be desirable for each ministry or big research institution to set up a system for the "study of mobility and decompartmentalization" and for the DGRST to set up a system for "employment, mobility and decompartmentalization"

in charge of gathering data in this area, establishing objective criteria, and formulating directives and stipulations eliminating possible obstacles.

Thus, in the field of public research the allocation of research budgets and auditing and evaluation procedures could take better into consideration mobility and decompartmentalization efforts; in enterprise research incentives should favor the recruitment of personnel by technical centers, the semipublic and the private sectors with the help of public research institutions.

In the private sector we must promote the type of personnel management which would make it possible for a person, without damaging his career, to be assigned for a while to public research or administration. At the same time, public research individuals must participate in the work of scientific councils of private enterprises.

Finally, we should see to it that the big governmental agencies, particularly the technical ones, pursue a policy of initial and permanent training which would take into consideration the importance of science and technology.

In the area of research contracts we must encourage all units--agencies, institutions, or industrial--in the use of subcontracting. All too frequently the natural tendency is the desire to do everything "at home," rather than looking outside for the team which could undertake with dynamism and from a new angle the tackling of a problem to be resolved. A research market fed by numerous "job masters" would constitute a powerful trump card for the dynamic units and a guarantee for progress for the entire economy. This would also be an efficient way of meeting others, when teams belonging to different organizations join efforts for the implementation of a single contract, the result being a strong synergy.

Psychological factors are among the essential mainsprings for effective research: the belief of the researchers in their usefulness, their enthusiasm, their intellectual curiosity, and their will to promote their discovery. Openness and decompartmentalization are contributing factors.

Increased research facilities would offer us the opportunity to improve the balance among the different parties within our French system, to eliminate some of the partitions which separate the institutions and to improve quality and efficiency even further.

The recommendations of the commission are in the sense of giving priority to quality accompanied by growth.

Research and innovation have priority in insuring the very survival of our economy. They have priority, for the corresponding financing will determine our economic and social progress and preserve our international competitiveness.

In order to avoid a situation in which, in a few years the living standard of the French people may be affected, the production machinery underutilized, and

employment in the productive sector threatened, in this difficult world which exists and will continue to exist we must firmly mobilize energies and means for research and innovation. On this subject all French people must be united. Our control of technological change and therefore, of our freedom, depend on it.

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OVERALL RESEARCH, DEVELOPMENT EXPENDITURES DISCUSSED

Paris AFP SCIENCES in French 25 Sep 80 pp 1, 6

[Report: "Scientific Research Policy and Organization"]

[Excerpts] Paris. French overall research and development appropriations will exceed 50 billion francs. This sum will include all civilian and military, public and private expenditures in this area to be incurred by France in 1981 in the field of research and development. In 1980 this national effort (as indicated in Table IV) was assessed at 48 billion francs. The budget-financed part for 1980 will total 31,230,000,000 francs, of 5.8 percent of the state budget. On the basis of such a "good budget" for research planned for 1981, this percentage will be somewhat higher.

France ranks fourth, following the United States, Japan, and the FRG, among the OECD in terms of volume of research in financial terms. Its 1978 per capita outlays averaged 700 francs.

In terms of gross national product (GNP) in 1978 domestic research and development outlays accounted for no more than 1.8 percent, compared with 2.4 percent in the United States, 2.2 percent in the FRG, 2.1 percent in Great Britain, and 1.9 percent in Japan. According to Pierre Aigrain, the draft 1981 budget "is such that the target of 2.2 percent may be rcached by 1985."

It would be quite desirable for the enterprises to increase their research and development efforts. In 1979, enterprises accounted for 42 percent of the 43.5 billion francs spent by France on research and development. Suggestions were made in 1979, in the Fouroux Report in particular, providing tax incentives which would let the enterprises deduct from their taxes a certain share of their increased research and development expenditures. The proposal was rejected because of the need for tax measures needed to provide a boost to the economy. Nevertheless, there has been a substantial increase in the amount of research funds.

Table IV
French Research Effort in 1980

1. Sources of Financing of the 1980 National Research and Development Effort

The financing of the 1980 efforts of the nation in the area of research and development may be broken down as follows (excluding taxes):

11. The State Effort	
- Military budget	11 250 MF
- Civilian budget	18 660
- Supplementary budget (posts, telegraph and telephone)	1 320
Total budget financing	31 230
Adjustment for converting from budgetary credit to factual outlays (estimate)	-3 230
Total State Contribution	28 000 MF
12. Efforts of Other Economic Agencies (estimate)	
- Technical centers	800 MF
- Enterprises	
. public	3 500
. private	15 700
Total	20 000
Total national research and development effort	48 000 MF

(1) After modifications of the content of the interministerial research package.

2. Analysis of Budget Financing of 1980 Research and Development

Million Francs	1980
I. Military budget	11 250
II. Research package	10 330
- Personnel	5 975
- Infrastructure and indirect means	1 125
- Basic and exploratory research	2 215
. operational credits	1 315
. Major scientific equipment and international commitments	900
- Finalized research	1 015
. public research	605
(operational credits	545
(major equipment	60
. aid to industry	410
III. Civilian Nonpackage Research	2 970
IV. Technological Development	6 680
- Space program	1 028
- Nuclear electric power	2 635
- Civil aeronautics	800
- Posts, telegraphs and telephones	1 320
- National Research Utilization Agency	417
-Informatics	425
-Innovation and Technology Office	47
-Oceanography	8
Total civilian	19 980
Total general	31 230

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